

Lecture-9

Acid-Base Balance Disturbances

When you request an acid-base or blood gas analysis, always remember to send

1. Arterial or capillary blood: To measure arterial pO_2 and pCO_2 values.
2. A heparinised sample: Most O_2 is carried in red blood cells so we need an anti-coagulated sample.
3. In a sealed syringe: To prevent O_2 and CO_2 diffusing out of the sample.
4. On ice : To prevent ongoing red cell metabolism from generating a lactic acidosis.

Acid-Base Balance Disturbances

There are several classifications of acid-base balance disturbances. The main ones are shown in table:

Parameter	Types of disturbance
Blood pH	Acidosis Alkalosis
Primary disturbance	Respiratory Metabolic Mixed Combined
Compensation	Compensated Subcompensated Non- compensated

According to compensatory changes of different types of acid-base balance disturbances

Type of disturbance	[H ⁺]	pH	Primary disturbance	Compensation
Metabolicacidosis	↓	↓	↓[HCO ₃]	↓pCO ₂
Metabolicalkalosis	↓	↑	↑	↑
Respiratoryalkalosis	↑	↑	↑	↓
Respiratoryacidosis	↓	↑	↓	↓

Respiratory Alkalosis

Respiratory alkalosis is defined as a pH greater than 7.45 with a pCO₂ less than 35 mm Hg. Respiratory alkalosis appears if removal of CO₂ is greater than production by tissues.

Parameters	Acute Respiratory Alkalosis	Chronic respiratory Alkalosis
pCO ₂	↓	↓
[HCO ₂]	Normal or ↓	↓
pH	↑	↑Or normal

Any condition that causes hyperventilation can result in respiratory alkalosis. These conditions include:

1. Increased metabolic demands, such as high fever, sepsis, pregnancy, or thyro-toxicosis
2. Psychological responses, such as anxiety or fear.
3. Central nervous system lesions, raised intracranial pressure, which may stimulate the respiratory fever.
4. Hysterical overbreathing.
5. Mountain sickness.
6. Lack of oxygen, hypoxia.
7. CNS injury, neuroinfection, cerebral haemorrhage, brain tumor.
8. Salicylate overdosage or other respiratory stimulants (theophyllin, estrogens).
9. Excessive artificial respiration
10. Pulmonary diseases: lobar pneumonia, asthma, pulmonary oedema, pulmonary collapse or fibrosis, pulmonary embolism.

Respiratory Acidosis

Respiratory acidosis is defined as a pH less than 7.35 with a PaCO₂ greater than 45 mm Hg. Acidosis is caused by an accumulation of CO₂, lowering the pH of the blood.

Parameteres	Acute Respiratory Acidosis	Chronic Respiratory Acidosis
pCO ₂	↑	↑
Hco ₂	normal	↑
pH	↓	↓

Any condition that results in hypoventilation can cause respiratory acidosis. These conditions include:

1. Respiratory center depression:

- Central nervous system depression related to head injury, neuroinfection, stroke, brain tumor, increased intracranial pressure.
- Central nervous system depression related to medications such as narcotics, tranquilizers, barbiturates, or anesthetics;

2. Neuromuscular diseases:

- Impaired respiratory muscle function related to spinal cord injury, or neuromuscular blocking drugs, poliomyelitis, Guillian-Barr syndrome, muscular dystrophy, hypokalaemia.

3. **Chest abnormalities:** Hypoventilation due to pain, chest wall injury/deformity (kyphoscoliosis), abdominal distension, pneumothorax, hydrothorax.

4. Pulmonary disorders:

- Atelectasis, pneumonia, bronchitis, asthma, pulmonary oedema, emphysema, or bronchial obstruction

- Massive pulmonary embolus.

Metabolic Alkalosis

Metabolic alkalosis is defined as a bicarbonate level greater than 26 mEq/liter with a pH greater than 7.45, either an excess of base or a loss of acid within, the body can cause metabolic alkalosis.

Causes of Metabolic Alkalosis

1. Saline- responsive urinary chloride excretion < 20 mmol/l (chloride depletion):

- **Gastric losses:** vomiting, mechanical drainage, gastric aspiration

- **Diarrhoeal states:** venous adenoma, congenital chloridiarrhoea

- **Diuretic therapy:** e.g. furosemide, chlorothiazide, bumetanide

- **Cystic fibrosis** (high sweat chloride)

- Acute or chronic milk-alkali syndrome (in patients, who drink lots of milk or Calcium –

Containing antacids.

- Exogenous alkali (sodium citrate, lactate, gluconate, acetate).

- Massive blood transfusion.

- Bicarbonate ingestion massive or with renal insufficiency.

2. Saline-unresponsive urinary chloride excretion < 20 mmol/l (Potassium depletion/

Mineralocorticoid excess):

- Primary hyperaldosteronism (Conn's syndrome);

- Secondary hyperaldosteronism;

- Cushing's syndrome;

- Eddie's syndrome (hypermineralocorticoidism, hypertension and hypokalaemic

Compensatory mechanism: hypoventilation.

Metabolic Acidosis

Metabolic acidosis is defined as a bicarbonate level of less than 22 mEq/l with a pH of less than 7.35. Metabolic acidosis is caused by either a deficit of base in the bloodstream or an excess of acids, other than CO₂.

Causes of Metabolic Acidosis

1. Kidney dysfunction, that results in retention of nonvolatile acids; impairment of the ability of renal tubules to generate bicarbonate ions (distal renal tubular acidosis); renal losses of bicarbonate (proximal renal tubular acidosis).
2. Increased endogenous organic acids production - ketoacidosis due to insulin deficiency (diabetic ketoacidosis) or due to lack of glycogen (starvation); enzyme defects; lactic acidosis due to tissue hypoxia.
3. Intake of exogenous acids, their precursors or substances, that block certain metabolic pathways, that leads to nonvolatile acids accumulation in the body (poisoning by salicylate, ammonium chloride, methanol, ethanol, ethylene glycol).
4. Gastrointestinal bicarbonate loss: diarrhoea, GIT drainage.

Compensatory mechanism: hyperventilation through stimulation of central chemoreceptors